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Integrated inversion of temperature and wireline logs

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The basic rationale of petrophysical inversion from logging data is to describe the tool response by some equation linking the volumetric composition of the rock to its physical properties. This technique has been successfully applied in reservoir evaluation using nuclear, acoustic, and electrical log data. Temperature logging, on the other hand, has played only a minor role in this scheme, generally only to provide correct values for temperature dependent properties. This lack of interest stems from the fact that virgin rock temperatures are difficult to measure, but also because of fundamental differences in the response equations for temperature. Whereas regular wireline logs sample a local rock volume, temperature also depends non-locally on thermal conductivity and additonal parameters, such as heat-flow and surface temperature.

If undisturbed temperature data is available it is instructive to create a petrophysical rock model that is consistent with respect to both petrophysical and thermal data. An inversion algorithm is presented to carry out this task. The forward model contains various tool responses and incorporates variable layering and inclusion of shoulder effects. A Bayesian inversion algorithm together with a regularisation solves the inverse problem. This formulation allows inclusion of prior information as well as rigorous computation of errors in the rock composition. Depending on the number of logs and noise present in the log data, the accuracy of the volumetric rock composition is 5 to 10 %. The algorithm is tested using synthetic and real data sets.